TRILOBITES FROM THE SHOLESHOOK LIMESTONE (ASHGILL) OF SOUTH WALES

by DAVID PRICE

ABSTRACT. Eight trilobite species based on type material from the Sholeshook Limestone are redescribed and two new species erected. For the first time a topotype pygidium is illustrated for *Stenopareia bowmanni* (Salter). *Tretaspis moeldenensis* Cave is retained as a distinct species; a topotype pygidium of this form is also figured for the first time and histograms given of selected fringe characters. The previously undescribed pygidium of *Lehua*? *princeps* (Reed), is very similar to that of the type species *L. vincula* (Barrande) and supports the assignment of the species to *Lehua* made previously on the basis of cranidia only. Topotype material of *Pseudosphaerexochus* (*Pseudosphaerexochus*) *juvenis* (Salter) is distinguished from *P.* (*P.*) *octolobatus* (M'Coy) and a pygidium tentatively referred to the species. It is not evident that the two syntypes of *Sphaerexochus*? *boops* Salter are specimens of the same species; that from Sholeshook is not a sufficient basis for the recognition of a distinct species. *Flexicalymene cavei* sp. nov. and *Kloucekia extensa* sp. nov. are distinguished from other Ashgill species of those genera. Lectotypes are selected for *K. robertsi* (Reed) and '*Acidaspis*' *turnbulli* Reed. The latter species is tentatively referred to *Diacanthaspis*; it shows great similarity to *D. decacantha* (Angelin) of which it may ultimately prove a junior synonym.

IN common with many other Upper Ordovician Limestones in Wales, the Sholeshook Limestone of South Wales early attracted the attention of palaeontologists on account of its rich shelly faunas. Trilobites from the formation were among those described and figured by J. W. Salter in an appendix to the *Geological Survey Memoir* of 1848 and some of these were subsequently redescribed and refigured by Salter in various publications between that date and 1867. Later, between 1904 and 1908, F. R. C. Reed described and figured some of the trilobites from the Sholeshook Limestone collected by V. M. Turnbull and then recently presented to the Sedgwick Museum, Cambridge.

Most of these older species have not been redescribed; some of them are stratigraphically important. It is the aim of this paper to deal with species erected on type specimens from the Sholeshook Limestone, both from the original type material where this needs redescription and from topotype and other material which has subsequently become available, including material collected by the author.

Apart from those included among the early forms described by Salter and Reed, the only other species to have been so far erected on type material from the Sholeshook Limestone is *Tretaspis moeldenensis* Cave, 1960. The redescription of this species is made desirable both by the recently much-increased knowledge of the genus *Tretaspis* (Ingham 1970, pp. 39–45) and by the stratigraphical importance attached to it by the author in recent discussion of the age and correlation of the Sholeshook Limestone (Price 1973, pp. 238–239). In addition, new species of *Flexicalymene* and *Kloucekia* from the Sholeshook Limestone are erected herein.

The stratigraphical terminology used throughout is that of Price (1973). That is to say, the term Sholeshook Limestone is used to include the argillaceous-calcareous or arenaceous-calcareous horizons developed between the Mydrim Shales and the Slade and Redhill Mudstones at Sholeshook (Haverfordwest, Pembrokeshire) and in the area around Llandowror (Carmarthenshire) and that developed between the type

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Robeston Wathen Limestone and the Slade and Redhill Mudstones at Robeston Wathen. Thus defined, the formation has a diachronous base and overlies the Mydrim Shales unconformably. The base of the normally succeeding Slade and Redhill Mudstones is also diachronous and to the north and west of Haverfordwest this formation contains strata laterally equivalent to the Sholeshook Limestone. The Sholeshook Limestone is thought to range in age from the upper part of Zone 1 to probably Zone 3 of the Cautleyan Stage of the Ashgill Series.

These descriptions of type trilobites from the formation are intended as a preliminary work to description of the Sholeshook trilobite fauna as a whole.

The material upon which this paper is based is housed in the following museums, the prefixes for whose specimen-numbers are indicated in brackets: British Museum (Natural History) (BM), Hunterian Museum, Glasgow (HM), Institute of Geological Sciences (GSM), and the Sedgwick Museum, Cambridge (SM). The following descriptions are based on all available material in these collections. Maps showing detailed localities for specimens collected by the author and for other well-localized material have been given elsewhere (Price 1973, text-figs. 1–5) and it is to these that the locality numbers cited in the text refer.

SYSTEMATIC PALAEONTOLOGY

Family ILLAENIDAE Hawle and Corda, 1847
Subfamily ILLAENINAE Hawle and Corda, 1847
Genus STENOPAREIA Holm, 1886

Type species. (Original designation) *Illaenus linnarssonii* Holm, 1882.

Stenopareia bowmanni (Salter, 1848)

Plate 112, figs. 1–8, ?9

1848 *Illaenus bowmanni* Salter (*pars*), p. 339, pl. 8, fig. 1, 1*a*; non figs. 2, 3.
1851 *Dysplanus centrotus*? (Dal.); M'Coy, pl. 1E, figs. 19, 19*a*.
1866 *Illaenus bowmanni*, Salter; Salter (*pars*), pl. 18, fig. 8*a*; non fig. 8.
1867 *Illaenus* (*Dysplanus*) *bowmanni* Salter; Salter (*pars*), p. 185, pl. 28, figs. 10, 12; non fig. 7.
1885 *Illaenus bowmanni* Salt.; Marr and Roberts, pp. 480, 481.
1909 *Illaenus bowmanni* Salt.; Strahan *et al*., table p. 58.
1914 *Illaenus bowmanni* Salt.; Strahan *et al*., table p. 63.
1933 *Illaenus bowmanni* Salter; Reed, pp. 121–135.
1938 *Illaenus* (*Dysplanus*) *bowmanni* Salter; Stubblefield, p. 33.
1961 *Stenopareia bowmanni* (Salter); Whittard, p. 217, pl. 31, figs. 1, 2.
1970 *Stenopareia* cf. *bowmanni* (Salter); Ingham, pp. 23–25, pl. 4, figs. 1–7, ?8.
1973 *Stenopareia bowmanni* (Salter); Price, tables 1–4.

Lectotype. Subsequently designated and refigured by Whittard (1961), GSM 24553, original of Salter 1848, pl. 8, fig. 1, 1*a*; from the Sholeshook Limestone, probably at Sholeshook. (The locality may possibly have been Llandowror; Stubblefield (1938, p. 33, footnote) refers to some slight doubt. In the present author's opinion, the lithology of the matrix would strongly indicate Sholeshook as the locality.)

Horizons and localities. Around Llandowror the species is known from about 14 m above the base of the Sholeshook Limestone in the Mylet Road section (locality 24a of Price 1973) and similar horizons at Craig-y-deilo quarry (localities 18c, d) through to horizons near the top of the formation at Faynor (locality 20). At Sholeshook it ranges from about the middle of the Sholeshook Limestone through to the highest part of the formation and the basal part of the overlying Slade and Redhill Mudstones at Prendergast (localities 8a, b).

An incomplete pygidium (Pl. 112, fig. 9) from an outcrop of 'Bala Limestone' at Fron, near Whitland, Carmarthenshire (see Strahan *et al*. 1914, fig. 5) appears also to belong with this species.

Description. Cranidium semi-elliptical to sub-parabolic in dorsal outline, generally about nine-tenths as long (sag.) as wide (tr.), moderately convex transversely; in longitudinal profile the convexity increases as the cranidium is declined more steeply anteriorly (Pl. 112, figs. 2, 3). Anterior margin strongly and evenly rounded. Glabella with only slight independent convexity (tr.) occupies about one-half total cranidial width (tr.) at posterior margin. Axial furrows deep and rounded in profile posteriorly, shallowing anteriorly and extending to between one-third and one-half the cranidial length; sub-parallel over most of length but sigmoidally curving at first adaxially and then outwards before dying out (Pl. 112, figs. 4–6). On internal moulds, a sharp furrow across the posterior end of the glabella represents the inner margin of the posterior doublure (Pl. 112, figs. 1, 4). Immediately anterior to this is a broad (sag. and exsag.) and very shallow (?occipital) furrow, only clearly seen near the axial furrows; deep pits, probably representing articulating processes, are developed where it crosses these (Pl. 112, fig. 4). Posterior border furrows broad (exsag.) and prominent; narrowest adaxially, broadening outwards; behind them are narrow (exsag.), convex borders. Palpebral lobes small, situated far back at about their own length (exsag.) from the posterior margin. Short posterior branches of facial suture apparently directed straight back from palpebral lobes; anterior branches running directly forwards at first, then gradually converging in smooth curves (Pl. 112, fig. 5) to become confluent antero-ventrally. Free cheeks sub-triangular, almost twice as long (exsag.) as wide (tr.), convex (tr. and exsag.), broadly rounded at genal angles. Eyes short (exsag.) and strongly convex abaxially (Pl. 112, fig. 5), standing rather high and dropping steeply to the general level of the free cheeks. Doublure broad and flexed close to ventral surface of exoskeleton. Surface of cranidium usually smooth or, in some internal moulds, finely granular.

Thorax, hypostoma, and rostral plate not known from Sholeshook material.

Pygidium transversely sub-parabolic in dorsal outline, about three-quarters as long (sag.) as wide (tr.), only gently convex transversely; in longitudinal profile (Pl. 112, fig. 7) only gently convex over anterior two-thirds of length, then dropping steeply posteriorly before flattening slightly near the posterior margin. Axis occupies about one-third of total width (tr.) anteriorly. Axial furrows broad (tr.) and shallow at anterior margin; very ill-defined behind but appearing to converge rapidly. Fulcrum about half-way between furrows and lateral margins. Beyond this, anterior margins of pleural lobes deflected back through about 45° and then gradually curving into the lateral margins. Facets narrow and very steeply declined. Antero-lateral corners of pleural lobes partly crossed by broad, shallow furrows extending obliquely back from anterior ends of axial furrows. Doublure broad, occupying about one-half total pygidial length along saggital line where partially crossed by faint shallow groove (on ventral mould) running from posterior margin; with fine, closely-spaced, sub-parallel terrace-lines. Inner margin incompletely seen but scalloped, apparently with three broad (tr.) lobes separated by distinct cusps (Pl. 112, fig. 8).

Discussion. In his description of topotype material of '*Illaenus*' *bowmanni*, Reed (1933, pp. 124–125) described in some detail two pygidia from the Geological Survey collections which he presumed were those used by Salter for his description in the 1867 Monograph. Only one of these, the smaller, GSM 24555 (Pl. 112, figs. 7, 8 of this paper) is here accepted as belonging to *S. bowmanni*. The other, GSM 24557 (a partial external mould), is considered to belong to the species listed by the author (Price 1973, tables 1–4) as *Illaenus* (*Parillaenus*) cf. *fallax* Holm, where the form of the pygidium is known from a complete articulated specimen.

Cranidia described and figured by Ingham (1970, pp. 23–25, pl. 4, figs. 1–3, 6, 7) from Zones 2 and 3 of the Cautley Mudstones are closely similar to those described above, though no pygidia are known from South Wales which show traces of transverse grooves on the pygidial axis as does the original of Ingham's plate 4, fig. 4. This pygidium, however, resembles those figured here in general form and proportions and Ingham's material appears acceptable to the present author as *S. bowmanni*.

Two complete specimens, SM A41852a, b and A41853, from the Ashgill Series of Llanwddyn in the Berwyn Hills, originals of M'Coy (1851, pl. 1E, figs. 19, 19*a*) one of which was refigured by Whittard (1961, pl. 31, fig. 2), are also accepted as belonging here.

Family TRINUCLEIDAE Hawle and Corda, 1847
Subfamily TRETASPINAE Whittington, 1941
Genus TRETASPIS M'Coy, 1849

Type species. *Asaphus seticornis* Hisinger, 1840.

Tretaspis moeldenensis Cave, 1960

Plate 112, figs. 10–12; Plate 113, figs. 1–4; text-fig. 1

1909 *Trinucleus fimbriatus* Murch.; Strahan *et al.*, p. 56.
1960 *Tretaspis moeldenensis* Cave, pp. 334–337, pl. 10, figs. 1–7.
1961*a* *Tretaspis kiaeri* Størmer *radialis* Lamont; Dean (*pars*), pp. 122–125.
1962 *Tretaspis kiaeri* Størmer *radialis* Lamont; Dean, p. 86, pl. 9, figs. 2–4.
?1970 *Tretaspis* cf. *moeldenensis* Cave; Ingham, pp. 54–55, pl. 8, figs. 21–26; pl. 9, figs. 1–7; text-figs. 14*c*, 19.
1973 *Tretaspis moeldenensis* Cave; Price, tables 3 and 4.

Holotype. Figured by Cave 1960, pl. 10, figs. 1 and 3, SM A50668, from the basal Sholeshook Limestone of Moldin, near Llandowror (locality 25).

EXPLANATION OF PLATE 112

Figs. 1–8. *Stenopareia bowmanni* (Salter). 1, SM A77827a, internal mould of cranidium, low Sholeshook Limestone of Llandowror (locality 18c), dorsal view, ×1. 2, SM A31496, internal mould of cranidium, highest Sholeshook Limestone of Prendergast Place (locality 8b), Haverfordwest, lateral view, ×1. 3, SM A77905a, internal mould of cranidium, Sholeshook Limestone, Sholeshook, lateral view, ×1. 4, SM A77573, internal mould of cranidium, horizon and locality as for fig. 2, dorsal view, ×1. 5, BM I.16446, internal mould of cranidium and right free cheek, Sholeshook Limestone of Sholeshook cutting, dorsal view, ×1. 6, BM I.16433, internal mould of cranidium, horizon and locality as for fig. 5, dorsal view, ×1. 7 and 8, GSM 24555, internal mould of incomplete pygidium, horizon and locality as for fig. 3, lateral and dorsal views, ×2.

Fig. 9. ?*Stenopareia bowmanni* (Salter), SM A31642, internal mould of incomplete pygidium, 'Bala Limestone', quarry at Fron, near Whitland (Carmarthenshire), dorsal view, ×1.

Figs. 10–12. *Tretaspis moeldenensis* Cave, SM A35500a, internal mould of incomplete cephalon, basal Sholeshook Limestone of Moldin (locality 25), near Llandowror, lateral, dorsal, and anterior views, ×4.


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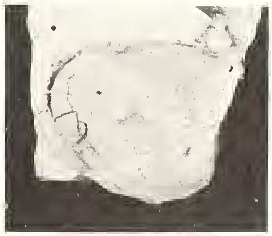
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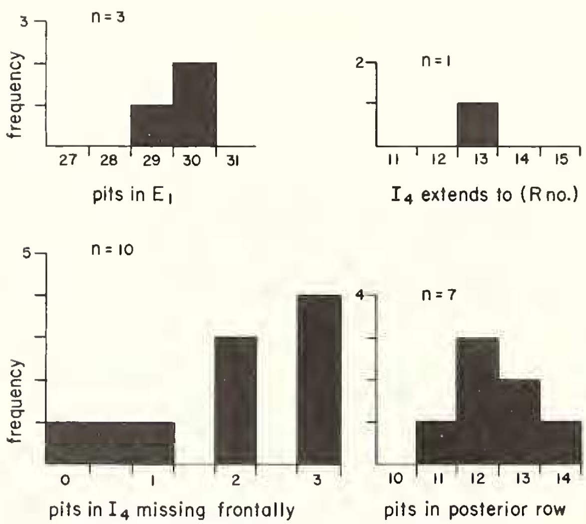
PRICE, Ashgill trilobites

Horizons and localities. The species is restricted to a thin basal horizon of the Sholeshook Limestone in its development around Llandowror. Apart from Moldin, it is known also from road sections near Mylet and Pentre-howell (localities 24a and 17).

Description. Cephalon sub-semicircular in dorsal outline. Pseudofrontal lobe of glabella occupies almost two-thirds total cephalic length (sag.); surface smooth; convex (tr. and sag.) but never approaching sub-spherical, rather longer (sag.) than broad (tr.) in dorsal view, bearing small, apically situated median tubercle. Occipital ring narrow and strongly convex (sag. and exsag.), oriented postero-dorsally, curving forwards abaxially. Occipital furrow broad (sag. and exsag.) and shallow mesially, abaxially containing deep, ovoid apodemal pits. 1p lateral glabellar lobes short (tr.), gently convex (exsag.), abaxially rounded. 1p lateral furrows in form of strongly oblique shallow slots, diverging posteriorly. 2p lobes only gently convex (exsag.), set transversely, narrowest adaxially, broadening outwards. 2p furrows in form of large, shallow, ovoid, anteriorly diverging depressions which constrict the posterior margin of the pseudofrontal lobe. 3p lateral furrows not seen. Axial furrows broad (tr.), particularly posteriorly; anteriorly containing small, deep fossulae. Genal lobes sub-quadrant shaped, smooth, moderately convex (tr. and exsag.), not overhanging fringe; bearing lateral tubercles, rather larger than the median tubercle, at about the level of the 2p lateral furrows; dropping steeply to broad (exsag.) posterior border furrows which abaxially contain large posterior fossulae. Posterior borders set transversely, narrow (exsag.) and only gently convex adaxially; becoming broader and more prominent outwards where deflected postero-laterally. Fringe broad, comprising steeply inclined, convex genal roll and well-developed, gently concave brim; there are long genal prolongations and slender genal spines. Internal moulds show a broad, deep girder with strong, closely spaced terrace-lines. In front of the axial furrows seven pit-arcs are present, E_{1-2}, I_{1-4}, I_n (in the notation of Ingham 1970, p. 40). On one specimen (Pl. 113, fig. 3) I_4 is also present in front of the glabella but on all other specimens up to three I_4 pits (half-fringe) are absent frontally (text-fig. 1). The I_4 arc persists laterally to around R13 where it merges with the I_n arc. All pits



TEXT-FIG. 1. Histograms of selected fringe characters in *Tretaspis moeldenensis* Cave, topotype material including that utilized by Cave (1960). n is the sample number for each character chosen. All histograms show half-fringe data. (Where columns on the horizontal scale are numbered alternately, this is to allow for half-pits in the count, i.e. a pit on the centre-line.)

arranged in strict radial alignment until genal prolongations are reached; on the upper lamella, pits of arcs E_2, E_1, and I_1 are contained in deep radial sulci. On the genal prolongations there is a tendency for these sulci to contain only the E_1 and E_2 pits and the general radial alignment of the fringe breaks down due to the intercalation of extra pits between the I_1 and I_2 arcs; the fringe, thus expanded, may have from 11 to 14 pits in the posterior row. The E_1 arc contains from 29 to 30 pits in the half-fringe. In the posterior row, and occasionally in the posterior-most two rows, the E_2 pit is absent. Generally concentric ridges (lists) are not developed, or are only very weakly developed, between the internal pit-arcs on the upper lamella. On the lower lamella the internal pits are arranged in strong radial sulci (Pl. 112, figs. 10–12) which, on the genal prolongations, become disrupted by the additional pits inserted between the I_1 and I_2 arcs.

Thorax unknown. Pygidium (Pl. 113, fig. 4) sub-triangular in outline, broad (tr.), the sagittal length only about one-third of the maximum width; postero-lateral margins moderately convex; bluntly rounded posteriorly. Axis narrow, only about one-fifth maximum pygidial width (tr.), tapers gradually posteriorly at about 25°, only moderately convex (tr.). Ring furrows shallow, gently arched forward; each contains a pair of deep apodemal pits a short distance from the axial furrows; axis bears eight such pairs of pits in all, the posterior-most pair usually only weakly developed. Axial furrows shallow. Pleural lobes flat, usually with four faintly defined, broad (exsag.) pleural ribs visible.

Discussion. Dean (1961*a*, 1962, see synonymy) described a form from the Pusgillian Stage of Cross Fell which he identified as *T. kiaeri radialis* Lamont and synonymized with *T. moeldenensis*. Ingham (1970, pp. 55–57) has indicated, however, that *T. radialis* may differ from *T. moeldenensis* and be more likely to prove identical with a closely related but distinct and stratigraphically younger form present in both the North of England and South Wales, the *T.* cf. *radialis* of Ingham (1970, pp. 55–57, pl. 9, figs. 8–20; text-figs. 14*d*, 19) and Price (1973, tables 1–4). Dean's material, which has a non-reticulate, not highly inflated pseudofrontal glabellar lobe, only six pit-arcs in front of the glabella and apparently similar pit counts, is extremely like that described here and Dean's synonymy with *T. moeldenensis* seems acceptable to the present author, this name being best retained pending clarification of the relationship with *T. radialis*.

Ingham (1970, see synonymy) has described a closely similar form from the highest Pusgillian and Cautleyan Zone 1 of the Cautley Mudstones. This form differs primarily in that the I_4 pit-arc is complete frontally in well over half the sample (Ingham 1970, p. 55; text-fig. 19). In the author's opinion, this form and that from Cross Fell discussed above are probably both to be regarded as belonging to local populations of the geographically widespread species *T. moeldenensis*.

Two other related forms are *T. colliquia* Ingham (1970, pp. 53–54, pl. 8, figs. 8–20; text-fig. 14*b*) from the lower part of the Pusgillian Stage at Cautley and the form described by Dean (1961, p. 125, pl. 8, figs. 2, 6–8) as *T. kiaeri duftonensis* from the Pusgillian Stage of Cross Fell. The former differs in possessing a narrower fringe and a faintly reticulated glabella and in lacking an extensively developed I_4 arc; the latter has a much higher peripheral pit count and, again, the pseudofrontal glabellar lobe is reticulated.

Family CHEIRURIDAE Hawle and Corda, 1847
Subfamily CHEIRURINAE Hawle and Corda, 1847
Genus LEHUA Barton, 1916

Type species. Cheirurus vinculum Barrande, 1872.

Lehua? *princeps* (Reed, 1908)

Plate 113, fig. 12

1908 *Typhloniscus princeps* Reed, p. 433, pl. 14, figs. 1–3.
1916 *Lehua princeps* (Reed); Barton, p. 129.
1958 *Typhloniscus princeps* Reed; Whittard, p. 115.
1971 *Lehua*? *princeps* (Reed); Lane, p. 36, pl. 7, fig. 17*a*, *b*.
1973 *Lehua*? *princeps* (Reed); Price, table 2.

Holotype. (By monotypy) SM A31617a, b, counterpart moulds of cranidium, from the Sholeshook Limestone of Sholeshook railway cutting.

Discussion. Lane (1971) has refigured the holotype and redescribed this and another cranidium from the same locality. Contrary to Reed (1908) and Whittard (1958), he has considered this species to possess visual organs, the palpebral lobes being placed far forwards, opposite the frontal lobe, and adjacent to the axial furrows. The present author has examined the two cranidia in question and agrees with Lane's interpretation.

No further material of the cranidium has become available but an incomplete pygidium (Pl. 113, fig. 12) from the Sholeshook Limestone of Sholeshook railway cutting appears to belong with this species. The axis is moderately convex (tr.), wide (tr.) anteriorly, and tapers back at about 40°; it comprises three axial rings and a terminal piece. Rings narrowest (sag. and exsag.) and most convex over mesial region which is transverse; abaxially they widen considerably, are less convex, and are slightly deflected posteriorly. Convex (tr.) terminal piece sub-parabolic in outline; reaches posterior margin. Ring-furrows over most of course broad and deep, abaxially narrowing and deflected posteriorly. Axial furrows broad (tr.) and deep adjacent to axial rings, much shallower over region of terminal piece. Pleural regions narrow; three broad ribs continue beyond them as broad, flat pleural spines. Interpleural furrows deep, curving outwards and backwards and widening (exsag.) abaxially. Pleural furrows short (tr.) and deep, commencing at inner anterior corners of ribs and curving outwards convex posteriorly. Surface ornamentation of large, scattered granules absent in furrows.

This pygidium is very similar in general form to that of the type species *L. vincula* (Barrande) described by Prantl and Přibyl (1947, p. 19, pl. 3, figs. 1, 2) from the Dobrotivá Formation (Llandeilo) of Bohemia. It differs in the axial region in lacking paired tubercles on the axial rings and in having a larger and less-pointed terminal piece. The incompleteness of the pleural spines on the Sholeshook specimen prevents more detailed comparison but the author feels that the otherwise strong similarity with the pygidium of the Bohemian form supports the assignment of the species to the genus *Lehua* made by previous workers on the basis of cranidia only.

Subfamily ECCOPTOCHILINAE Lane, 1971
Genus PSEUDOSPHAEREXOCHUS Schmidt, 1881
Subgenus PSEUDOSPHAEREXOCHUS Schmidt, 1881

Type species. Sphaerexochus hemicranium Kutorga, 1854.

Pseudosphaerexochus (*Pseudosphaerexochus*) *juvenis* (Salter, 1848)

Plate 113, figs. 5–7, 8?, 9?

1848 *Sphaerexochus juvenis* Salter (*pars*), pp. 344–345, pl. 7, figs. 1, 1*a*, 2, 3, 3*a*; non fig. 3*b*.
1852 *Cheirurus clavifrons* Dalman; Salter, p. 3.
1864 *Cheirurus* (*Actinopeltis*) *juvenis* Salter; Salter (*pars*), pp. 67–69, pl. 5, figs. 10, 11; non figs. 9, 12.
1866 *Cheirurus juvenis* Salter; Salter, p. 323, pl. 18, figs. 1, 2.
1881 *Pseudosphaerexochus juvenis* (Salter); Schmidt, p. 152.
1881 *Pseudosphaerexochus juvenis* Salter; Salter, p. 521, pl. 18, figs. 1, 2.
1885 *Cheirurus juvenis* Salt.; Marr and Roberts, lists pp. 480, 481.
1914 *Cheirurus juvenis* Salt.; Strahan *et al.*, table, p. 63.
1938 *Pseudosphaerexochus juvenis* (Salter); Stubblefield, p. 32.
1965 *Pseudosphaerexochus juvenis* (Salter); Whittington, pp. 40–41, pl. 12, figs. 2–5, 8, 15.
?1968 *Pseudosphaerexochus* sp. ind.; Whittington, pp. 102–104, pl. 31, figs. 13, 17.
1971 *Pseudosphaerexochus* (*Pseudosphaerexochus*) *juvenis* (Salter); Lane, p. 47.
1973 *Pseudosphaerexochus* (*Pseudosphaerexochus*) *juvenis* (Salter); Price, tables 1–4.

Lectotype. Subsequently designated by Whittington 1965, p. 40, GSM 24534, internal mould of cranidium from the Sholeshook Limestone of Sholeshook; figured Whittington 1965, pl. 12, figs. 2, 4, 8.

Horizons and localities. Cranidia of the type regarded below as belonging to this species range from about the middle of the Sholeshook Limestone at Sholeshook (locality 9e and railway cutting) to the high Sholeshook Limestone at Prendergast (locality 8c) and also occur in low horizons of the Sholeshook Limestone around Llandowror (localities 18b, c). Pygidia tentatively referred to this form are known from the railway cutting at Sholeshook and the low Sholeshook Limestone of Craig-y-deilo quarry (locality 18c).

Discussion. The range in morphology of cranidia of *Pseudosphaerexochus* found in the Sholeshook Limestone is considerable. Some clearly belong to *P.* (*P.*) *octolobatus* (M'Coy) and have the characteristic sub-circular, longitudinally convex glabella seen in material described by Whittington (1965, pp. 37–40, pl. 10, figs. 14, 15, 17–20; pl. 11, figs. 1–13) from the Rhiwlas Limestone and by Lane (1971, pp. 48–50, pl. 8, figs. 1–8) from the Starfish Bed of Girvan. At the other extreme of the morphological range are cranidia in which the glabella is much longer (sag.) than wide (tr.), frontally sub-parabolic in outline and in lateral profile does not overhang the anterior border (Pl. 113, figs. 5–7). Cranidia with these characteristics the present author has considered to belong to *P.* (*P.*) *juvenis*. The distinction of this form from *P.* (*P.*) *octolobatus* and from other species on the basis of the cranidium, however, is complicated by the poor preservation of the lectotype and the great range of variation shown by Sholeshook specimens (see also comments by Whittington 1965, p. 41). Many of the cranidia are to some extent distorted (Pl. 113, fig. 6), but others with an elongate, frontally parabolic glabella not overhanging the anterior border show no signs of distortion (Pl. 113, fig. 5). There are also cranidia which show glabellar characters intermediate between those just described and those of *P.* (*P.*) *octolobatus* (see Pl. 113, fig. 8 here and Whittington 1965, pl. 12, figs. 3, 5, 15).

The problem is further complicated by the presence in the Sholeshook Limestone (as noted by Whittington 1968, p. 104, pl. 31, fig. 17) of pygidia apparently indistinguishable from that of a form from the Lower Tre-wylan Beds of the Llansantffraid-ym-Mechain district (*Pseudosphaerexochus* sp. ind. of Whittington 1968, pp. 102–104, pl. 31, fig. 13). There is a strong possibility that these are the pygidia of *P.* (*P.*) *juvenis*, particularly as there is, as yet, no other cheirurid cranidium known from the Sholeshook Limestone to which a pygidium has not been assigned. Because, however, no entire exoskeleton is known from Sholeshook and because of the difficulty of comparing the poorly preserved cranidium of the Llansantffraid specimen with the cranidia here referred to *P.* (*P.*) *juvenis*, the present author is inclined to follow Whittington's (1968, p. 104) note of caution and to regard the pygidium only tentatively as that of *P.* (*P.*) *juvenis*. A further example of this pygidium is figured here (Pl. 113, fig. 9). Further collecting may clarify the status of the Llansantffraid specimen.

The cranidium of the form described by Whittington (1965, p. 39, pl. 11, fig. 14; pl. 12, figs. 1, 6, 7) from the Dolhir Mudstones is not like those here thought to belong to *P.* (*P.*) *juvenis* and the form of the pygidium of this specimen is not clearly seen; it appears possible to the present author that this and the Llansantffraid specimen may represent different species.

Pseudosphaerexochus? *boops* (Salter, 1864)

Plate 113, figs. 10, 11

1851 *Ceraurus clavifrons* (Dal. Sp.); M'Coy (*pars*), p. 154, pl. 1F, fig. 12.
1864 *Sphaerexochus*? *boops* Salter, p. 79, pl. 6, figs. 27, 28.
1873 *Sphaerexochus boops* Salter; Salter, p. 50.
1891 *Sphaerexochus boops* J. W. Salter; Woods, p. 151.

Discussion. Sphaerexochus? *boops* was founded by Salter (1864) on two syntypes which are refigured here. One of these, GSM 24560 (Pl. 113, fig. 10) is the poorly

EXPLANATION OF PLATE 113

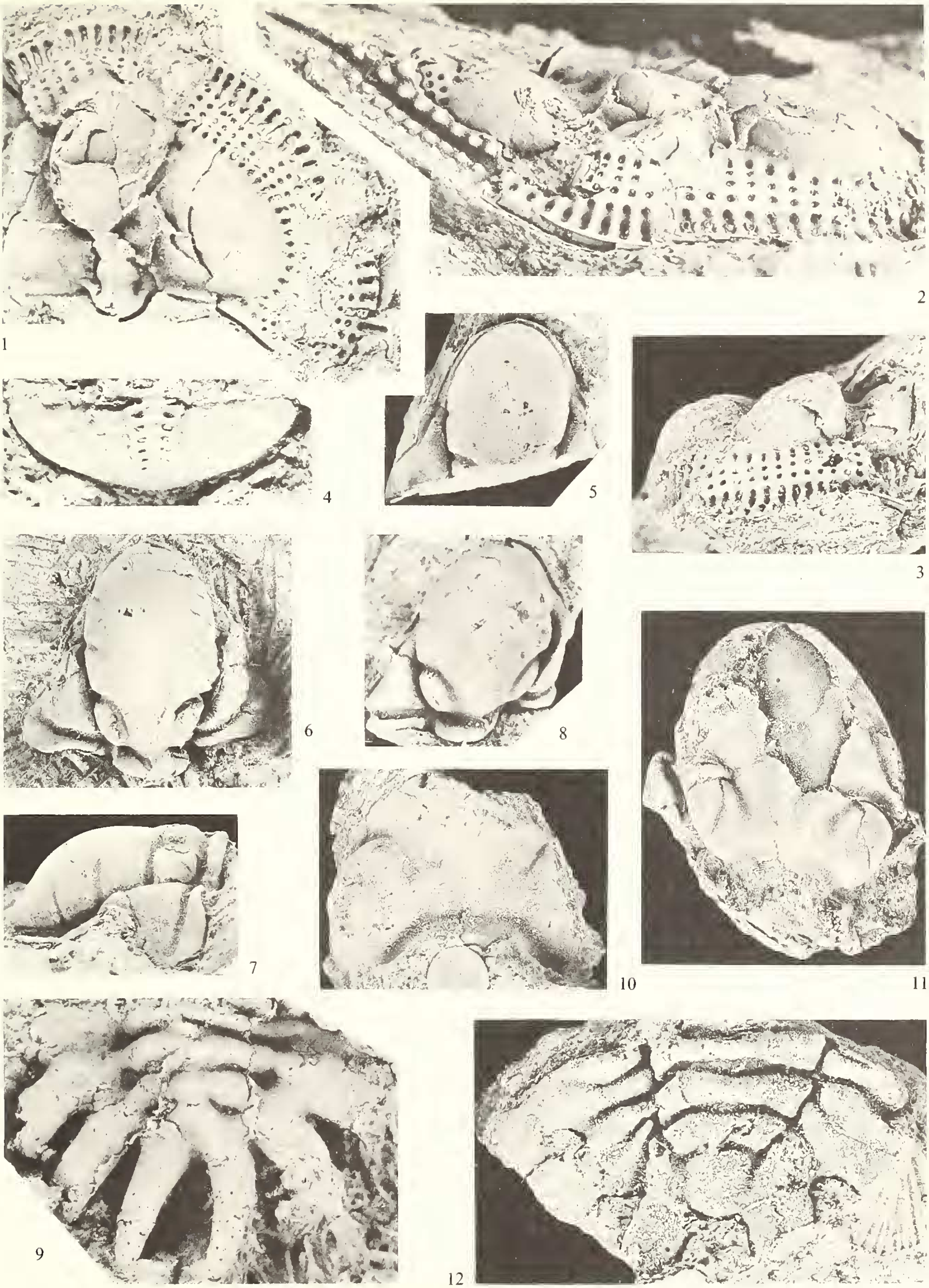
Figs. 1–4. *Tretaspis moeldenensis* Cave. 1, HM A9803a, incomplete cephalon with upper lamella of fringe preserved, basal Sholeshook Limestone of Moldin (locality 25), near Llandowror, dorsal view, ×4. 2, HM A9804a, two superimposed partial cephala with portions of fringe upper lamellae preserved, horizon and locality as for fig. 1, antero-lateral oblique view, ×4. 3, SM A50670a, partial cephalon with portion of fringe upper lamella preserved showing frontally complete I_4 pit-arc, horizon and locality as for fig. 1, anterior view, ×4. 4, SM A77717, internal mould of pygidium, horizon and locality as for fig. 1, dorsal view, ×4.

Figs. 5–7. *Pseudosphaerexochus* (*Pseudosphaerexochus*) *juvenis* (Salter). 5, SM A77569, incomplete internal mould of cranidium, middle part of Sholeshook Limestone (locality 9e), Sholeshook, dorsal view, ×2. 6 and 7, SM A31418, internal mould of cranidium, Sholeshook Limestone of Sholeshook railway cutting, dorsal and lateral views, ×2.

Figs. 8–9. ?*Pseudosphaerexochus* (*Pseudosphaerexochus*) *juvenis* (Salter). 8, BM It.9226, internal mould of cranidium, horizon and locality as for fig. 5, dorsal view, ×2. 9, SM A31405b, cast from external mould of incomplete pygidium, horizon and locality as for figs. 6–7, dorsal view, ×3.

Figs. 10–11. *Pseudosphaerexochus*? *boops* (Salter). 10, GSM 24560, partial internal mould of cranidium, syntype, Sholeshook Limestone of Sholeshook, dorsal view, ×3. Original of Salter 1864, pl. 6, fig. 27. 11, SM A41905, crushed internal mould of cranidium, syntype, Applethwaite Beds of Applethwaite Common, dorsal view, ×3. Original of M'Coy 1851, pl. 1F, fig. 12 and Salter 1864, pl. 6, fig. 28.

Fig. 12. *Lehua*? *princeps* (Reed), SM A31451, internal mould of incomplete pygidium, horizon and locality as for figs. 6–7, dorsal view, ×4.



PRICE, Ashgill trilobites

preserved, partial internal mould of a cranidium from the Sholeshook Limestone of Sholeshook. The incompleteness of the specimen makes comparisons difficult but the present author considers that it could possibly be a partial cranidium of *P.* (*P.*) *octolobatus* (M'Coy). Lane (1971, pl. 8, fig. 1*a*, *b*) has recently figured a specimen of that species in which the basal lateral glabellar lobes are prominent, large and rounded in dorsal view and in which the occipital furrow is arched forward mesially though not as strongly as in the Sholeshook specimen. The Sholeshook specimen, however, does show clear signs of distortion. This specimen cannot serve as a sufficient basis for the recognition of a distinct species.

It is far from evident that the other syntype, SM A41905 (Pl. 113, fig. 11), a more complete but badly crushed cranidium from the Ashgill of Applethwaite Common, which also appears to belong to *Pseudosphaerexochus*, is conspecific with the Sholeshook specimen. The glabella of this specimen is oval in dorsal outline; the basal lateral glabellar lobes are relatively smaller than in the Sholeshook specimen, occupying well under one-third of the glabellar width (tr.) on that level, and angular antero-laterally. The 1p lateral furrows are wider and more distinct abaxially, shallowing as they curve back and reaching the occipital furrow as broad (tr.), indistinct depressions. The 2p lateral lobes appear to be slightly shorter (exsag.) than the 1p and the 3p lateral lobes about two-thirds the length (exsag.) of the 2p. The 2p and 3p furrows are shallow; other details of lobation are not clear. The glabella is ornamented, except in the furrows, with closely and evenly spaced tubercles of about 0·1 mm.

Clarification of the affinities of this specimen, and so of the status of *Sphaerexochus*? *boops* Salter, must await the collection and description of more complete and better-preserved material from Applethwaite Common.

Family CALYMENIDAE Edwards, 1840
Genus FLEXICALYMENE Shirley, 1936

Type species. (Original designation) *Calymene caractaci* Salter, 1865.

Flexicalymene cavei sp. nov.

Plate 114, figs. 1–15

1914 *Calymene* sp.; Strahan *et al.*, table p. 63, list p. 67, and table p. 70 (*pars*).
1960 *Flexicalymene* sp.; Cave, p. 334.
1973 *Flexicalymene* sp. nov.; Price, tables 1–4.

Holotype. SM A57050, internal mould of cranidium (Pl. 114, figs. 1, 2) from the basal Sholeshook Limestone of Moldin, near Llandowror (locality 25).

Horizons and localities. Not yet known from the basal few metres of the Sholeshook Limestone at Sholeshook or from the basal Slade and Redhill Mudstones to the north and west of Haverfordwest (localities 1–6). Otherwise ranges through the Sholeshook Limestone from the basal Moldin horizon (locality 25) through to the highest horizons at Prendergast (locality 8b), Robeston Wathen (10a), and Faynor (22) and into the overlying Slade and Redhill Mudstones of Prendergast (8a) and Glôg-y-frân (locality 15).

Diagnosis. Glabella (excluding occipital ring) rather broader (tr.) than long, extending slightly further forwards than convex parts of fixed cheeks. 1p lateral lobes subquadrate in outline, with acutely angular antero-lateral corners; 1p furrows not clearly bifurcating. 2p lobes elongated antero-laterally; 3p lobes small, transverse;

3p furrows very faint. Broad, steeply upturned anterior border. Eyes rather far forward, mid-length of palpebral lobes opposite antero-lateral corners of 2p lateral lobes; thorax of 13 segments. Pygidium with 5 axial rings and 4 well-marked pleural bands.

Description. Cephalon sub-semi-elliptical in dorsal outline, almost $2\frac{1}{2}$ times as wide (tr.) as long (sag.). Glabella, excluding occipital ring, occupying about two-thirds of cephalic length (sag.); sub-parabolic in dorsal outline, rather broader (tr.) than long (sag.); strongly convex transversely; in lateral profile dropping anteriorly in increasingly steep convex curve (Pl. 114, figs. 2, 6). Occipital ring widest (sag. and exsag.) mesially where arched gently forward; abaxially, posterior to the 1p lateral glabellar lobes, it curves forwards narrowing slightly. Occipital furrow broad (sag. and exsag.) and distinct mesially, a shallow U in profile; abaxially it curves around the posterior margins of the 1p lateral lobes, narrowing as it nears the axial furrows. 1p lateral glabellar lobes large, sub-quadrate in form with acutely angular antero-lateral corners; total length (exsag.) about one-third that of glabella (excluding occipital ring). The lobes have an independent convexity and drop steeply outwards to the axial furrows; this slope becomes less steep antero-laterally. 1p lateral furrows strongly curved posteriorly, deepest abaxially, shallowing inwards and continuing back as broad, shallow furrows to separate the basal lateral lobes from the median lobe of the glabella; not clearly bifurcating though the outline of the 2p lateral lobes is slightly constricted at their inner posterior margins. 2p lateral lobes only half the length (exsag.) of the 1p lobes; highest part of lobe has a sub-circular outline and is separated from the median lobe by a slight depression; from this area there is a moderately steep slope antero-laterally which has the effect of giving the lobe an elongate-oblique outline (Pl. 114, figs. 1, 3, 4). 2p lateral furrows posteriorly convergent, shallowing inwardly. 3p lobes small and set transversely, not distinctly separated from median lobe by a depression. 3p lateral furrows very faint. Frontal lobe moderately convex (tr. and sag.), much broader (tr.) than long (sag.), extending slightly further forwards than the convex parts of the fixed cheeks; the width (tr.) across its base is only slightly less than across the 3p lateral lobes. Behind, the median lobe narrows slightly posteriorly. Axial furrows deep, wide (tr.) and distinct, gradually converging anteriorly and with gentle, antero-laterally convex curvatures; ending in distinct antero-lateral pits situated slightly nearer to the 3p lateral furrows than to the anterior margin of the frontal lobe. Pre-glabellar area composed of short (sag. and exsag.), gently concave anterior border furrow and steeply upturned border (Pl. 114, figs. 2, 6). Anterior parts of fixed cheeks moderately convex (tr.) but standing much lower than the level of the glabella (Pl. 114, fig. 7). The slope down from the cheeks to the axial furrows becomes increasingly steep posteriorly and at the sharply angular inner posterior corner of the cheek it meets a similar steep slope down to the posterior border furrow; this latter slope becomes less steep abaxially. Posterior border furrows deep and distinct adaxially, shallowing outwards. Posterior borders narrow (exsag.) and strongly convex adaxially, broadening, flattening, and curving gently posteriorly outwards. Palpebral lobes rather far forward, their mid-lengths on the level of the antero-lateral ends of the 2p lateral lobes. Suture gonatoparian; anterior branches run forward from the eye in gradually converging gentle curves; posterior branches run outwards for a short distance in posteriorly convex curves then are deflected to curve strongly postero-laterally. Free cheeks sub-quadrant shaped, gently convex (tr. and exsag.) with broad (tr.), moderately convex lateral border and broad, shallow border furrow.

Hypostoma (Pl. 114, fig. 8) with elongate (sag.), strongly convex (tr.) median body bearing a prominent pair of large maculae at about the mid-length; the anterior section is sub-parallel sided, behind the maculae the sides are strongly tapered posteriorly. Anterior margin transverse. Well-developed anterior wings. Lateral border furrow broad (tr.); broad, flat lateral border widest (tr.) posteriorly, dying out in front of maculae. Bifurcated posterior margin with prominent median notch.

Thorax of thirteen segments. Axis strongly convex (tr.), occupying one-third of total width (tr.) anteriorly, tapering only gradually posteriorly. Axial rings strongly convex (sag. and exsag.), arched forward mesially and curving again forwards abaxially to end in sub-quadrilateral axial lobes. Articulating furrows broad (sag. and exsag.), shallowest mesially, abaxially becoming deep slots between the axial lobes. Axial furrows broad (tr.) and rather shallow. Pleurae horizontal over inner portion; distally deflected strongly downwards and curved gently forwards (Pl. 114, fig. 9). Broad (exsag.), distinct pleural furrows commence near the axial furrows and run roughly parallel to the posterior margin dividing each pleura into a broad (exsag.), adaxially convex posterior band and a narrow anterior pleural band. Anterior bands bear, at the fulcrum, prominent articulating bosses (Pl. 114, fig. 9) which fit corresponding sockets in the posterior band of the next anterior pleura. Pleural furrows die out before reaching smooth, flattened, distally rounded pleural tips (Pl. 114, fig. 10).

Pygidium sub-triangular in dorsal view, convex (tr.), widest (tr.) on level of fourth or fifth axial ring, tapering strongly back to form an obtuse angle at the posterior margin. Axis strongly convex (tr.), tapering gradually posteriorly, formed of five axial rings and a sub-triangular terminal piece. Rings convex (sag. and exsag.), their dorsal surfaces rather flat in lateral view (Pl. 114, fig. 14); ring furrows broad and prominent. There are four well-defined pleural ribs, strongly curved posteriorly, narrowest adaxially, and broadening slightly outwards. Narrow (exsag.) pleural

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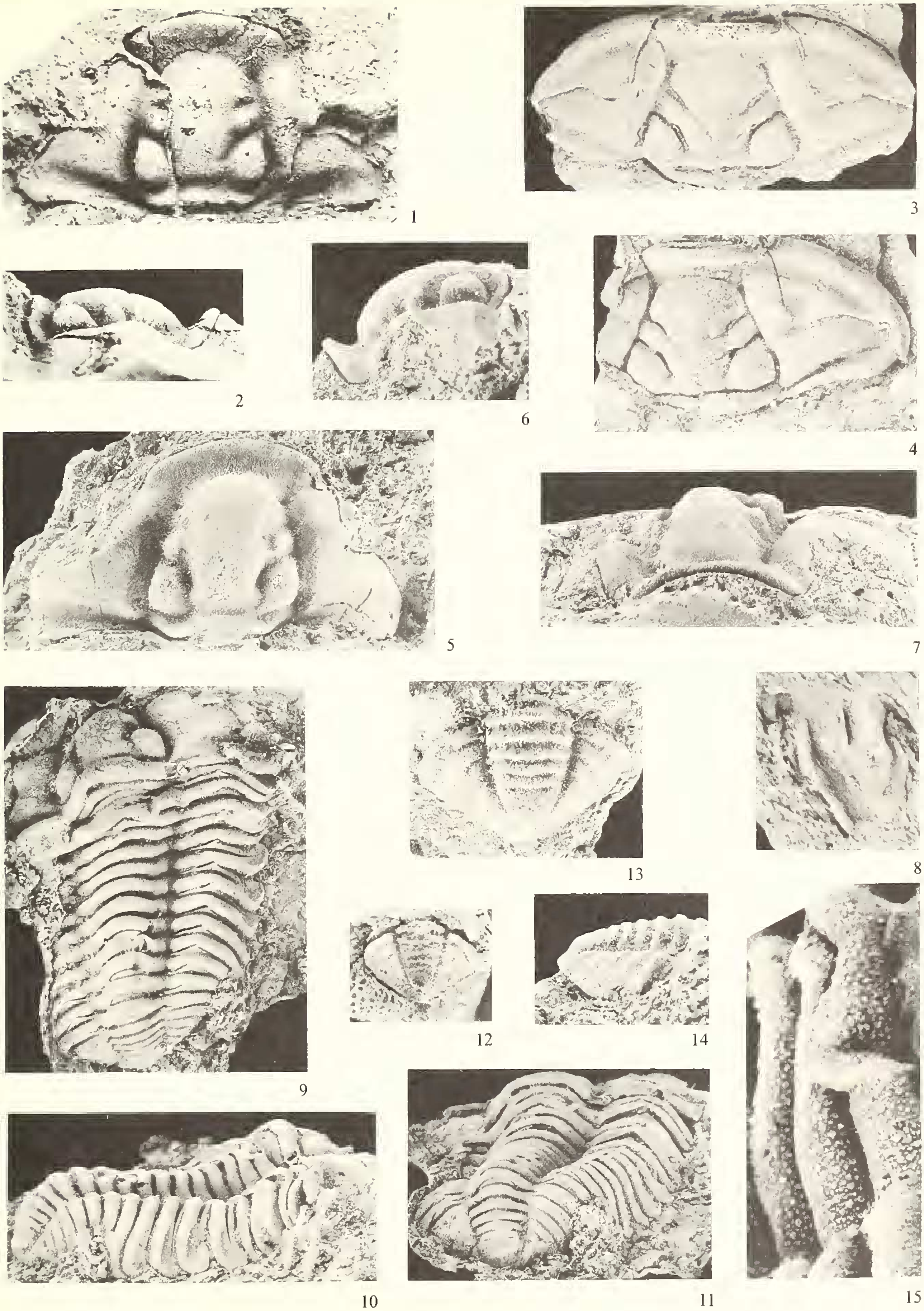
EXPLANATION OF PLATE 114

Figs. 1–15. *Flexicalymene cavei* sp. nov. 1 and 2, SM A57050, holotype, internal mould of cranidium, basal Sholeshook Limestone of Moldin (locality 25), near Llandowror, dorsal and right-lateral views, ×2. 3 and 4, HM A9686a, b, internal mould and cast from external mould of almost entire but slightly crushed cephalon, low Sholeshook Limestone, track south of Craig-y-deilo quarry, Llandowror (locality 18d), dorsal views, ×2. 5–7, SM A31390, internal mould of cranidium, Sholeshook Limestone of Sholeshook railway cutting, dorsal, left-lateral and anterior views, ×2. 8, BM It.9256b, cast from external mould of hypostoma, middle section of Sholeshook Limestone (locality 9e), Sholeshook, dorsal view, ×4. 9–11, SM A77824b, cast from external mould of almost complete articulated exoskeleton, Sholeshook Limestone horizon at Robeston Wathen (locality 10a), dorso-lateral oblique, right-lateral oblique, and posterior-oblique views, ×2. 12, SM A57052, internal mould of pygidium, horizon and locality as for figs. 1–2, dorsal view, ×2. 13 and 14, SM A31393, internal mould of pygidium, horizon and locality as for figs. 5–7, dorsal and right-lateral views, ×2. 15, detail of specimen illustrated in figs. 9–11 to show ornamentation, anterior axial rings, ×10.



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furrows run along the ribs in a position rather nearer to the posterior margin; these are strong abaxially but much weaker near the axial furrows. Anteriorly the pleural regions bear narrow, convex articulating bands with articulating bosses similar to those on the thoracic segments. A broad (tr.), gently convex, sub-parallel sided post-axial ridge extends forward to the anterior margin of the terminal piece.

The dorsal exoskeleton, with the exception of the major furrows, is uniformly ornamented with closely packed, irregularly spaced small granules, the largest about 0·125 mm.

Discussion. F. cavei sp. nov. is readily distinguished from two other British Ashgillian species *F. brevicapitata* (Portlock 1843) and ?*F. quadrata* (King 1923). The former species from the Killey Bridge Beds(?) of Desertcreat (see Shirley 1931, pp. 28–31, pl. 2, figs. 9, 10), has a shorter (sag.) glabella which does not extend as far forward as the fixed cheeks, transverse 2p lateral lobes, only slightly oblique 1p and 2p lateral furrows of which the 1p furrow bifurcates strongly, rather less prominent 3p lateral lobes, and a frontal glabellar lobe which rises very steeply from the pre-glabellar field; the 3p lateral furrows are stated to be absent. *F.*? *quadrata* (King 1923, pp. 504–505, pl. 26, figs. 1, 2) from the Ashgill Series of the south-west Berwyns differs in having a glabella which is frontally more quadrate in dorsal view, more strongly convex in lateral profile, and with almost equi-sized 2p and 3p lateral lobes and in possessing only twelve thoracic segments. As Dean (1962, p. 113) has commented, the systematic position and affinities of this form are rather uncertain.

Although the position of the eyes is rather far forward in *F. cavei*, it is not so far forward as in forms from the Maysville and Richmond Stages of the Cincinnati area, Ohio, usually assigned to *F. meeki* (Foerste 1910, p. 84, pl. 3, fig. 18; 1919, pl. 18, fig. 3) or related species such as *F. retrorsa* (Foerste 1910, p. 85, pl. 3, fig. 19; 1919, pl. 18, fig. 2); that is, opposite the 3p lateral lobes. Other differences also, particularly the less anteriorly convergent glabellar outline and the relatively longer frontal glabellar lobe, suggest that *F. cavei* is not closely related to these North American forms.

Family ENCRINURIDAE Angelin, 1854
Subfamily ENCRINURINAE Angelin, 1854
Genus ENCRINUROIDES Reed, 1931

Type species. (Original designation) *Cybele sexcostata* Salter, 1848.

Encrinuroides sexcostatus (Salter, 1848)

Plate 115, figs. 1–8

1848 *Cybele sexcostata* Salter, p. 343, pl. 8, fig. 10; non fig. 9.
1852 *Encrinurus sexcostatus* Salter, p. 4, pl. 1G, figs. 6, 7.
1853 *Encrinurus sexcostatus* Salter, pp. 1–5, pl. 4, figs. 1–12.
1866 *Encrinurus sexcostatus* Salter; Salter, p. 324, pl. 19, figs. 5, 6.
1909 *Encrinurus sexcostatus* (Salt.); Strahan *et al.*, table p. 58.
1914 *Encrinurus sexcostatus* (Salt.); Strahan *et al.*, table p. 63.
1938 *Encrinurus sexcostatus* Salter; Stubblefield, p. 35.
1950 *Encrinuroides sexcostata* (Salter); Whittington, pp. 535–538, pl. 68, figs. 7–16; text-fig. 2.
1960 *Paracybeloides* cf. *loveni* (Linnarsson); Cave (*pars*), faunal list p. 334.

1965 *Encrinuroides sexcostatus* (Salter); Whittington, pp. 42–43, pl. 12, figs. 9–14; pl. 13, figs. 1, 2.
1973 *Encrinuroides sexcostatus* (Salter); Price, tables 1–4, 7.

Neotype. SM A30695a, b, counterpart moulds of entire specimen, selected and figured by Whittington 1950, p. 535, pl. 68, figs. 7, 9, 10.

Horizons and localities. The species is abundant throughout most of the Sholeshook Limestone from the basal Moldin horizon of the Llandowror area upwards but has not yet been found in the highest horizons of the formation such as those at Prendergast (localities 8b, c) or Robeston Wathen (locality 10a) or in the overlying Slade and Redhill Mudstones. It does occur, however, in the basal Slade and Redhill Mudstones of localities (2, 3, 4) to the north and west of Haverfordwest.

Discussion. Material collected by the present author is similar to that described by Whittington (1950, 1965) from both the Sholeshook and the Rhiwlas Limestones. Cranidia show the pre-glabellar and longitudinal furrows (Pl. 115, figs. 2, 3) and free cheeks the anterior furrows (Pl. 115, figs. 4, 5) described by Whittington in 1950 (his fig. 2). The eye-stalks are distally expanded with visual surfaces composed of closely packed hexagonal lenses and surrounded by a prominent furrow (Pl. 115, figs. 5, 6). All the larger and well-preserved pygidia have seven pleural ribs and external moulds show that these and the axial rings are finely granulated.

Family DALMANITIDAE Vogdes, 1890
Genus KLOUCEKIA Delo, 1935

Type species. (Original designation) *Phacops phillipsii* Barrande, 1846.

Kloucekia robertsi (Reed, 1904)

Plate 115, figs. 9–14; Plate 116, figs. 1, 2

1904 *Phacops robertsi* Reed, pp. 106–109, pl. 5, figs. 1–7.
1904*a* *Phacops* (*Dalmanites*) *robertsi*; Reed, p. 384.
1905 *Dalmanites robertsi*; Reed, p. 177.
1914 *Phacops robertsi* Reed; Strahan *et al*., tables pp. 63, 75.
1973 *Kloucekia robertsi* (Reed); Price, tables 1, 2; p. 242.

Lectotype. (Here selected from among Reed's syntypes), SM A30706, internal mould of incomplete cephalon, original of Reed 1904, pl. 5, fig. 1, from the basal Redhill Mudstones of Prendergast Place (locality 8a), Haverfordwest.

Horizons and localities. The species is restricted to the uppermost part of the Sholeshook Limestone and the base of the overlying Slade and Redhill Mudstones at Prendergast (localities 8a, b) and the Slade and Redhill Mudstones of a similar horizon at Redhill quarry (locality 7).

Description. Cephalon sub-semicircular in dorsal outline. Glabella sub-pentagonal in outline, widest (tr.) across frontal lobe where maximum width is about equal to sagittal length (including occipital ring); only gently convex (tr.). Occipital ring convex (sag. and exsag.), in lateral profile stands above rest of glabella (Pl. 115, fig. 9), broadest (sag. and exsag.) mesially where posterior margin is gently concave, abaxially curves slightly forwards. Occipital furrow shallow, broad (sag. and exsag.), and gently arched forward mesially; abaxial portions in form of deep, broad (exsag.) apodemal slots set slightly oblique, posteriorly divergent, with their distal-most parts rather shallower. 1p lateral glabellar lobes sub-quadrilateral in outline, broadening (exsag.) abaxially, anterior margins gently convex. 1p lateral furrows strong, set slightly oblique, anteriorly divergent, except for short (tr.) adaxial portions which are deflected to become anteriorly convergent; main part of furrow a straight, deep apodemal slot with the adaxial-most portion shallower. 2p lateral lobes sub-parallel sided, both anterior and posterior margins slightly convex in such a way that the maximum width (exsag.) occurs near the adaxial end. 2p furrows shallow, transverse, gently curved, convex anteriorly; slightly deeper adaxially. 3p furrows shallow, sub-linear, strongly oblique, anteriorly divergent, so that 3p lobes rapidly broaden (exsag.) abaxially. All three pairs of furrows end adaxially close to the saggital line, leaving a narrow (tr.), sub-parallel sided median lobe indistinctly separated from the lateral lobes. Median lobe flat in lateral profile. Frontal lobe about twice as broad (tr.) as long (sag.), drops anteriorly in steep convex slope (Pl. 115, fig. 9) to very narrow (sag. and exsag.) but distinct anterior border furrow. Anterior border narrow (sag. and exsag.), sloping less steeply forward than frontal glabellar lobe. Axial furrows broad (tr.), moderately deep, diverging more strongly forward in front of the 1p lateral lobes. Cheeks sub-triangular in outline, dropping steeply to shallow lateral border furrows which merge with the less steep lateral borders. Cheeks drop near vertically to posterior border furrows which are deep and broad (exsag.) adaxially where they are set very slightly oblique, anteriorly divergent, but die out as they curve gently towards the genal angles. Genal angles bearing short (exsag.), rapidly tapering spines (Pl. 115, fig. 14; see also Reed 1904, pl. 5, fig. 4). Eye-lobes large, anterior edges in line with antero-lateral corners of 3p glabellar lobes, posterior edges in line with adaxial ends of 1p furrows. Palpebral lobes sub-semicircular; indistinct furrows separate broad (tr.), prominent palpebral rims which stand on about same level as glabella (Pl. 115, fig. 11). Visual surfaces sloping steeply, bearing circular, convex facets. Postero-laterally to the eye-lobes are broad (exsag.) semi-crescentic depressions (Pl. 115, figs. 10, 12) which die out as they cross the posterior branches of the facial suture. These latter run outwards and slightly forwards from the eye, sub-parallel to the posterior cheek margin. Anterior branches run forwards and slightly

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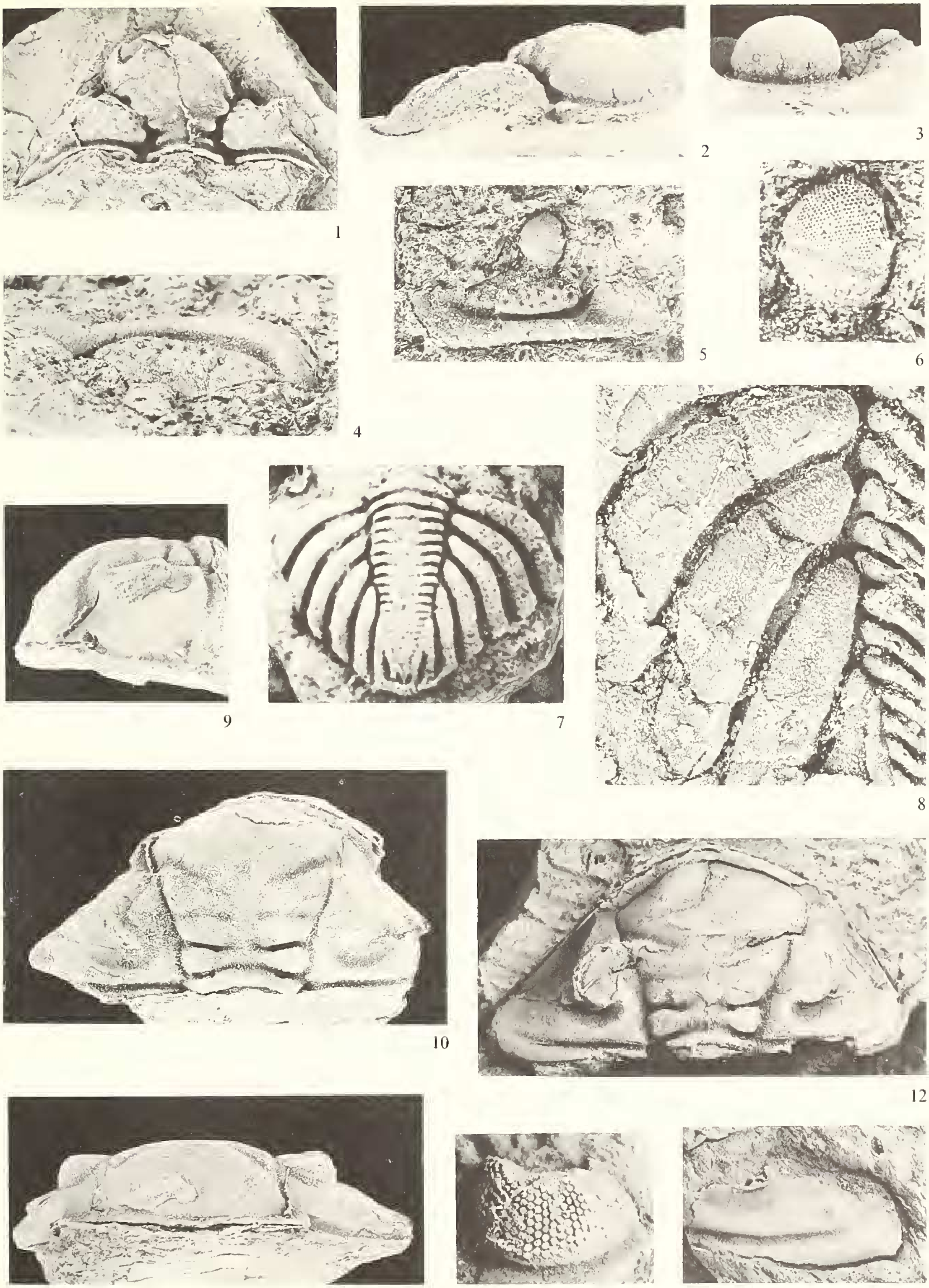
EXPLANATION OF PLATE 115

Figs. 1–8. *Encrinuroides sexcostatus* (Salter). 1, SM A31484, internal mould of cranidium, Sholeshook Limestone of Sholeshook railway cutting, dorsal view, ×2. 2, SM A77562, internal mould of partial cranidium, middle part of Sholeshook Limestone (locality 9e), Sholeshook, antero-lateral oblique view, ×2. 3, SM A77560, internal mould of cranidium, horizon and locality as for fig. 2, anterior view, ×2. 4, HM A9735, internal mould of right free cheek, low Sholeshook Limestone of Llandowror (locality 18d), dorsal view, ×3. 5 and 6, HM A9713, internal mould of right free cheek, horizon and locality as for fig. 4, anterior view, ×4 and detail ×10 to show form of visual surface of eye. 7, SM A77834b, cast from external mould of pygidium, low Sholeshook Limestone of Craig-y-deilo quarry, Llandowror (locality 18b), dorsal view, ×3. 8, SM A77922, part of cast from external mould of pygidium, horizon and locality as for fig. 2, dorsal view, ×6 to show ornamentation.

Figs. 9–14. *Kloucekia robertsi* (Reed). 9–11, SM A30706, lectotype, internal mould of incomplete cephalon, basal Slade and Redhill Mudstones of Prendergast Place (locality 8a), Haverfordwest, lateral, dorsal, and anterior views, ×2. Original of Reed 1904, pl. 5, fig. 1. 12, SM A77928, internal mould of cephalon, horizon and locality as for figs. 9–11, dorsal view, ×2. 13, internal mould of eye-lobe, horizon and locality as for figs. 9–11, oblique view, ×4 showing details of visual surface. 14, SM A77933, part of internal mould of right fixed cheek showing form of genal spine, horizon and locality as for figs. 9–11, dorsal view, ×2.



PRICE, Ashgill trilobites

outwards and then around the frontal glabellar lobe, joining anteriorly in a smooth curve coincident with the anterior border furrow. Cephalic doublure about as broad anteriorly as anterior border, narrowing rather posteriorly.

Thorax of eleven segments; tapering only gradually posteriorly in over-all width (tr.). Axis moderately convex (tr.), occupies about one-third of total width anteriorly. Dorsal surface of axial rings rather flat in lateral profile. Rings gently arched forward mesially, where narrowest (sag. and exsag.), broadening abaxially to form prominent axial lobes which are sub-quadrilateral in dorsal outline. Articulating furrows deep, broad (sag. and exsag.), rounded basally; shallowest mesially, deepening to form apodemal slots abaxially. Axial furrows broad (tr.). Inner parts of pleurae horizontal; outer parts deflected steeply ventrally and curving gently forwards, the tips smooth and abaxially rounded. Broad (exsag.), deep, basally rounded pleural furrows commence at the axial furrows, separating narrow posterior from wider (exsag.), adaxially convex anterior pleural bands, then run parallel to posterior margins of pleurae over most of their length, curving slightly forwards and dying out before reaching the pleural tips.

Pygidium sub-semicircular in dorsal outline, moderately convex (tr.); maximum width (tr.) on level of fourth axial ring. Axis moderately convex (tr.), anteriorly rather over one-quarter the maximum width (tr.) of the pygidium, strongly tapered posteriorly, extending almost as far back as the anterior margin of the doublure. At least nine axial rings present on figured specimen (Pl. 116, fig. 2); these strongly convex (sag. and exsag.), separated by broad ring furrows which are shallowest over the mesial third but become much deeper and slot-like abaxially; both become progressively less prominent posteriorly. Axial furrows broad (tr.), converge posteriorly at about 25°. Five broad (exsag.) pleural ribs are visible with broad, shallow rib furrows running along the mid-line and separated by broad, deep pleural furrows. Both sets of furrows die out laterally to leave a broad (tr.), smooth border. Doublure broad, widest anteriorly, narrowing slightly posteriorly (Pl. 116, fig. 2).

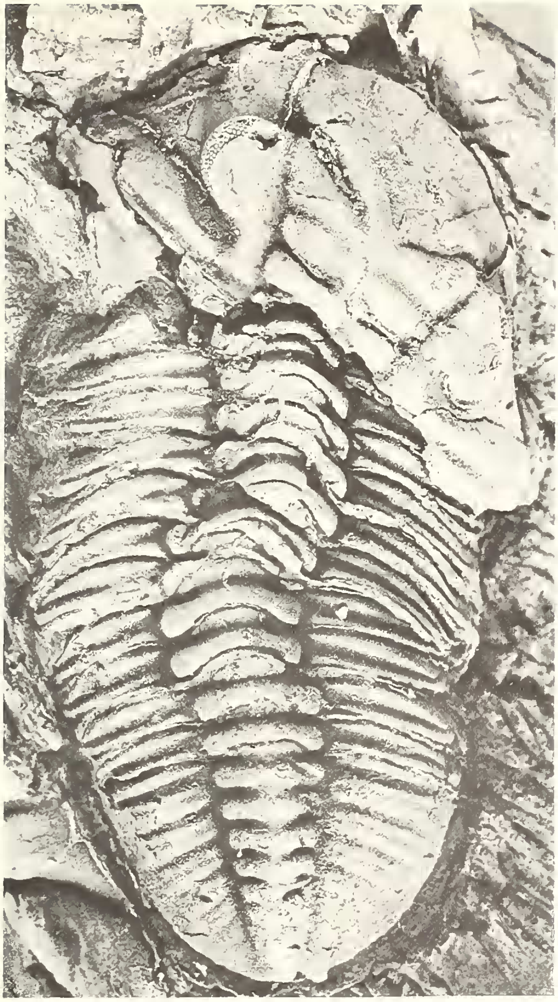
Discussion. K. robertsi differs from the type species *K. phillipsii* (Barrande) (see Whittington 1962, pp. 7–9; text-fig. 2) in having a relatively shorter (sag.) and broader (tr.) cephalon with a narrower (sag. and exsag.) occipital ring, a broader anterior border and longer (exsag.) palpebral lobes with their posterior ends relatively nearer to the axial furrows. The pygidium is similar in outline and convexity but differs in having a greater number of axial rings. It differs from the two British Caradocian

EXPLANATION OF PLATE 116

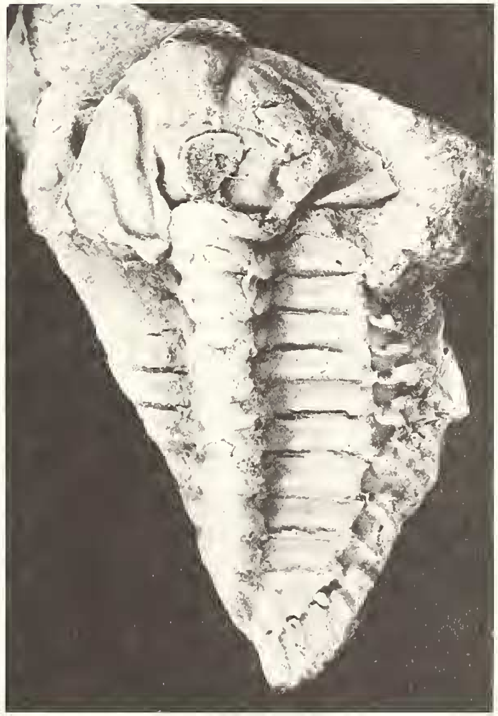
Figs. 1–2. *Kloucekia robertsi* (Reed). 1, SM A56041, internal mould of complete articulated exoskeleton, highest Sholeshook Limestone of Prendergast Place (locality 8b), Haverfordwest, dorsal view, ×2. 2, SM A30709, internal mould of pygidium, horizon and locality as for fig. 1, dorsal view, ×2. Original of Reed 1904, pl. 5, fig. 7.

Figs. 3–5. *Diacanthaspis*? *turnbulli* (Reed). 3, SM A30722, lectotype, incomplete internal mould of articulated exoskeleton, Sholeshook Limestone of Sholeshook, dorsal view, ×3. Original of Reed 1905, pl. 4, fig. 4. 4, GSM Pg.277, cast from external mould of incomplete thorax and anterior part of pygidial axis, Sholeshook Limestone, middle section of Sholeshook railway cutting, dorsal view, ×4. 5, SM A31363, internal mould of incomplete cranidium and external mould of partial thorax, Sholeshook Limestone of Sholeshook, dorsal view, ×4.

2



1



3

4

5

PRICE, Ashgill trilobites

species *K. harnagensis* (Bancroft) (see Dean 1961, pp. 321–324, pl. 49, figs. 9, 14; pl. 50, figs. 1–5) and *K. apiculata* (M'Coy) (see Whittington 1962, pp. 9–12, pl. 1; pl. 2, figs. 1–3, 5–7, 9–12) in that the cephalon is again relatively broader and shorter and has a more rounded anterior glabellar margin. The pygidium is more bluntly rounded posteriorly with a less convex and posteriorly less well-defined axis and lacks the caudal spine.

Kloucekia extensa sp. nov.

Text-fig. 2*a–k*

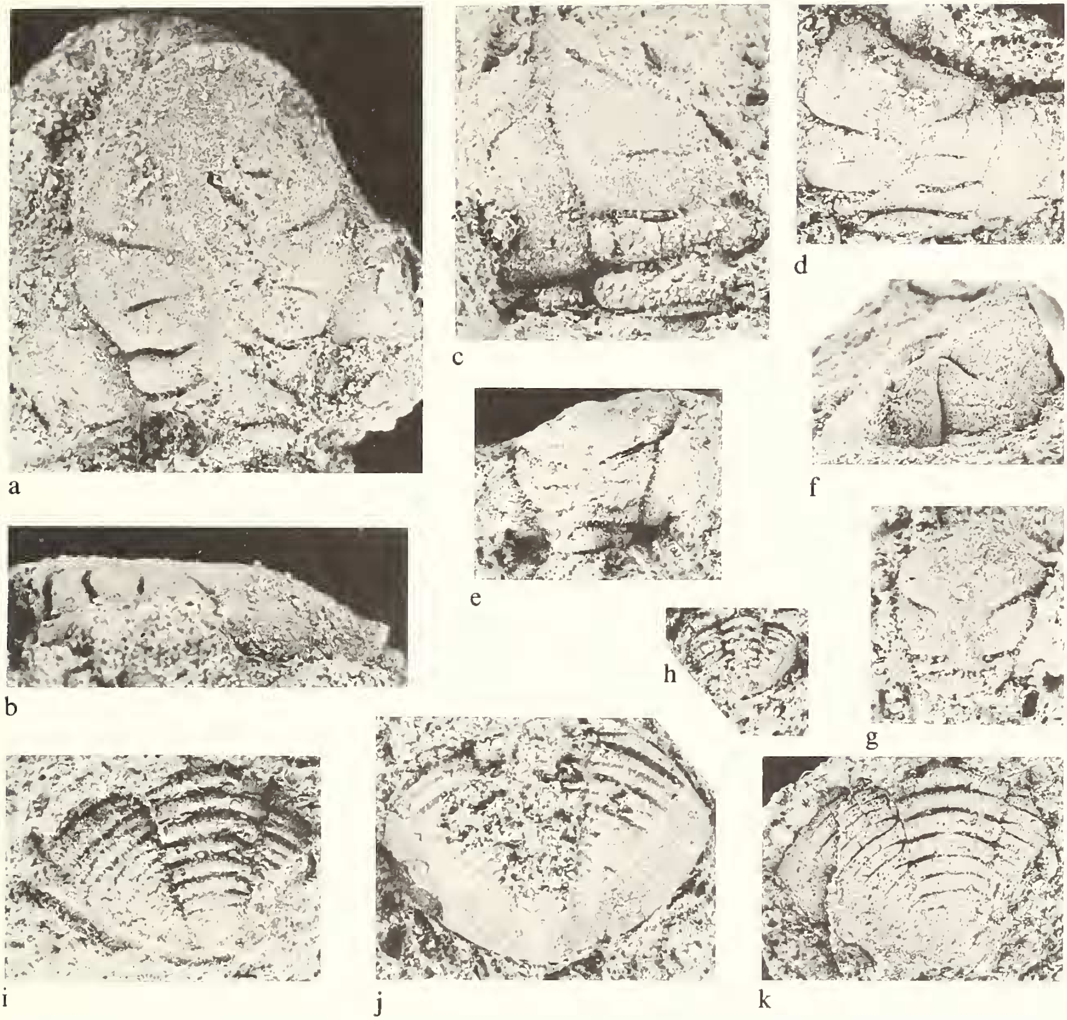
1973 *Kloucekia* sp. nov.; Price, tables 3, 4.

Holotype. HM A9682, external mould of incomplete cranidium (latex cast figured as text-fig. 2*a*) from the low Sholeshook Limestone of Craig-y-deilo quarry, Llandowror (locality 18c).

Other material. Nine incomplete cranidia and four pygidia, all from the low Sholeshook Limestone of either Craig-y-deilo quarry (localities 18b, c, d) or the Mylet road section (localities 24a, b), near Llandowror.

Diagnosis. Glabella attaining maximum width at level of 3p lateral lobes; 2p and 3p lateral lobes partly coalesced, short 2p lateral furrows not reaching axial furrows; 3p lateral furrows with moderately strong, even, posteriorly convex curvature; frontal lobe with strongly rounded anterior margin. Axial furrows narrow (tr.), with distinct change of course at level of 1p lateral furrows. Pygidium sub-semi-elliptical, gently convex (tr.) with flatter border, at least eight axial rings and six pleural ribs. Axis well defined posteriorly.

Description. Glabella moderately convex (tr.), longer (sag.) than wide (tr.), widest at level of mid-length of 3p lateral glabellar lobes. Occipital ring standing rather higher than rest of glabella in lateral profile; wide (sag. and exsag.) mesially, where the anterior margin is arched forward; abaxially narrowing and curving strongly forwards. Occipital furrow broad and shallow mesially, abaxially containing deep apodemal slots which are present in the internal mould as ovoid pits. 1p lateral glabellar lobes short (exsag.), sub-quadrilateral in dorsal outline, narrowest adaxially, broadening outwards. 1p lateral furrows in form of broad (exsag.), distinct slots set slightly oblique, anteriorly divergent, except for short (tr.) adaxial sections which are posteriorly divergent. 2p furrows narrow (exsag.), set transversely or very slightly oblique, posteriorly divergent; deepening abaxially, not reaching axial furrows. 2p and 3p lateral glabellar lobes thus fused abaxially. 2p lobes broadest (exsag.) near adaxial ends, narrowing slightly outwards. 3p furrows shallow and indistinct adaxially, broadening slightly outwards; set oblique, anteriorly divergent, with moderately strong, posteriorly convex curvatures. 3p lobes thus broadening abaxially. Frontal lobe of glabella sub-semi-elliptical in outline, sagittal length slightly less than three-quarters of maximum width which is attained on level of abaxial ends of 3p lateral furrows; anterior margin strongly rounded; in lateral profile dropping only gently anteriorly and flattening out near the anterior margin (text-fig. 2*b*). Central lobe of glabella narrow (tr.), flat in lateral profile. Axial furrows narrow (tr.) and shallow but quite distinct. Posteriorly they are curved around the abaxial ends of the 1p lateral glabellar lobes then, on the level of the 1p furrows, are deflected to run forwards and strongly outwards, at first linearly but opposite the anterior region of the 3p lateral lobes curving gradually adaxially. Palpebral lobes sub-semicircular with



TEXT-FIG. 2*a–k*. *Kloucekia extensa* sp. nov. *a–b*, HM A9682, holotype, cast from external mould of incomplete cranidium, low Sholeshook Limestone of Craig-y-deilo quarry, Llandowror (locality 18c), dorsal and right-lateral views, ×4. *c*, SM A78010, internal mould of partial cranidium, $9\frac{1}{2}$–10 m above base of Sholeshook Limestone in Mylet road section (locality 24a), near Llandowror, dorsal view, ×4. *d*, HM A9703, cast from external mould of partial cranidium, low Sholeshook Limestone, track south of Craig-y-deilo quarry, Llandowror (locality 18d), dorsal view, ×4. *e*, HM A9698, internal mould of incomplete cranidium, horizon and locality as for 2*d*, dorsal view, ×4. *f*, BM In.54701, cast from external mould of partial cephalon, low Sholeshook Limestone of Craig-y-deilo quarry (locality 18b or c), Llandowror, dorsal view, ×4. *g*, SM A77967, internal mould of incomplete cranidium, 14 m above base of Sholeshook Limestone in Mylet road section (locality 24a), near Llandowror, dorsal view, ×4. *h*, HM A9605, internal mould of small pygidium, higher part of Mylet road section (locality 24b), Llandowror, dorsal view, ×4. *i*, HM A9612a, internal mould of pygidium, horizon and locality as for 2*h*, dorsal view, ×4. *j*, HM A9606, internal mould of pygidium, horizon and locality as for 2*h*, dorsal view, ×4. *k*, HM A9612b, cast from external mould of incomplete pygidium, horizon and locality as for 2*h*, dorsal view, ×4.

narrow but distinct furrows separating long (exsag.), broad (tr.) palpebral rims. Anterior margins of eyes opposite antero-lateral corners of 3p lateral lobes, posterior margins opposite anterior parts of 1p lobes. Free cheeks drop steeply antero-laterally to broad, shallow, and indistinct border furrow and flat, near horizontal border. Anterior border narrow (sag. and exsag.). Posterior border furrow narrow (exsag.) and slot-like adaxially.

Pygidium sub-semi-elliptical in dorsal outline, sagittal length about three-quarters of maximum width which occurs at about level of fourth axial ring. Axis moderately convex (tr.); anteriorly occupies about one-third of total pygidial width. Tapers posteriorly at about 25°, apparently extending to the posterior margin. Axial rings strongly convex (sag. and exsag.), narrowest mesially, broadening outwards; separated by broad and mesially shallow ring furrows which deepen and become slot-like abaxially. At least eight such rings are present followed by an apparently smooth, convex (tr.) terminal piece. Axial furrows broad (tr.). Pleural lobes gently convex (tr.), with flatter border; crossed by six broad (exsag.) pleural ribs with broad, shallow inter-pleural furrows running roughly along the mid-line and separated by deeper pleural furrows. Both sets of furrows die out before reaching the lateral margin to leave a broad, smooth border.

Generally both internal and external moulds are smooth but one cranidium (text-fig. 2*c*) retains on the occipital ring and basal lateral glabellar lobe scattered tubercles of about 0·1 mm diameter.

Discussion. Several features of the glabellar region of *K. extensa* sp. nov.—the strong divergence of the axial furrows in front of the 1p lateral furrows, the level at which the maximum width is attained, the posteriorly convex, even curvature of the 3p lateral furrows and the relatively long (sag.) and anteriorly strongly rounded frontal lobe—are characteristic and serve to distinguish it from other species of the genus. It differs in all these respects from *K. poueyti* Destombes (1972, pp. 57–58, pl. 15, figs. 1–3, text-fig. 20) from the Upper Ashgill of Morocco and differs from this form also in that the pygidial axis is much better defined posteriorly and contains two or three more axial rings.

The pygidium is similar in over-all form to those of *K. phillipsii* (Whittington 1962, text-fig. 2*i*) and *K. robertsi* (Pl. 116, fig. 2 of this paper), differing mainly in being relatively longer (sag.) and, again, with the axis better defined at the posterior margin; that of *K. phillipsii* bears only five axial rings.

Family ODONTOPLEURIDAE Burmeister, 1843
Subfamily ODONTOPLEURINAE Burmeister, 1843
Genus DIACANTHASPIS Whittington, 1941*a*

Type species. (Original designation) *Diacanthaspis cooperi* Whittington, 1941*a*.

Diacanthaspis? *turnbulli* (Reed, 1905)

Plate 116, figs. 3–5

1905 *Acidaspis* (*Ceratocephala*) *turnbulli* Reed, pp. 99–100, pl. 4, figs. 4–7.
1973 *Diacanthaspis*? *turnbulli* (Reed); Price, tables 1, 2.

Remarks. Reed (1905) appears to have described *Acidaspis turnbulli* on the basis of two specimens, that figured on his pl. 4, fig. 4 and (p. 99) 'another specimen exhibiting some of the missing features'. These appear to be the only specimens of Reed's species in the Sedgwick Museum collections (one further specimen has been added by the author), other material from the Slade and Redhill Mudstones to which he refers on p. 100 having been referred to the form listed by the author (Price 1973, table 4) as *Primaspis* aff. *semievoluta* (Reed).

Lectotype. (Here selected from Reed's two syntypes), SM A30722, internal mould of incomplete, articulated exoskeleton (Pl. 116, fig. 3) from the Sholeshook Limestone of Sholeshook; original of Reed 1905, pl. 4, fig. 4.

Other material. SM A31363, internal mould of incomplete cranidium and external mould of partial thorax from the Sholeshook Limestone of Sholeshook, second specimen mentioned by Reed (1905, p. 99, see above); GSM Pg. 277, external mould of incomplete thorax from middle section of Sholeshook railway cutting; SM A77944, very poor internal mould of partial cranidium from Sholeshook (locality 9e).

Description. Cranidium broadest (tr.) posteriorly, moderately strongly convex (tr.). Sub-parallel sided median lobe of glabella defined by broad longitudinal furrows which are shallowest opposite the 2p lateral lobes; expanding (tr.) forwards into frontal lobe. Occipital furrow and occipital ring broad (sag. and exsag.), form of latter not clearly seen. 1p lateral glabellar lobes convex (tr.) with elongate-ovoid outlines, set slightly anteriorly divergent. 1p lateral furrows only faintly developed, anteriorly divergent; at their inner ends, where they meet the longitudinal furrows, shallow pits are developed. 2p lateral lobes with elongate-ovoid outlines; aligned sub-parallel. Axial furrows deep posteriorly where strongly anteriorly divergent, in front of mid-lengths of 1p lobes curving gradually adaxially; only faintly developed opposite the 2p lateral lobes. Fixed cheeks sub-crescentic in outline, convex (tr.), narrow (tr.) anteriorly, broadening, and becoming more strongly convex posteriorly, reaching a maximum width opposite the posterior parts of the 1p lateral lobes and then narrowing and curving strongly adaxially towards the occipital ring. Cheeks drop steeply postero-laterally to the posterior border furrows. Posterior borders narrow (exsag.) and strongly convex adaxially, curving gently forwards and very rapidly broadening (exsag.) outwards. Narrow, convex eye-ridges, separated from the cheeks by broad furrows, curve backwards to the palpebral lobes which are small and situated opposite the posterior parts of the 1p lateral lobes. Anterior branches of facial suture appear to run close to eye-ridge over most of its length; posterior branches curve outwards and strongly backwards to cross the posterior border near its adaxial end (part of the librigenal posterior border is present on the lectotype, Pl. 116, fig. 3). There appears to be a broad (sag. and exsag.) anterior border furrow.

Thorax of nine segments. Axis strongly convex (tr.), occupies less than one-third of total width (tr.) anteriorly and tapers only very gradually backwards. Axial rings broad (sag. and exsag.) and arched slightly forwards mesially, abaxially they curve forwards to form sub-quadrilateral axial lobes separated by deep slots which are the abaxial continuations of the mesially shallow and broad (sag. and exsag.) articulating furrows. Axial furrows broad (tr.) and shallow. Inner portions of pleurae straight and horizontal, composed of narrow (exsag.), convex anterior and broad, strongly convex posterior pleural bands separated by broad pleural furrows. The posterior pleural bands bear two prominent tubercles, one a short distance out from the axial furrow, the other at the fulcrum and give rise to long, gradually tapering, outwardly and backwardly directed pleural spines (Pl. 116, fig. 4). These pleural spines are rather broadened at their bases, adjacent to the fulcrum.

Pygidium incompletely known. First and second axial rings well defined (Pl. 116, fig. 3), appearing each to bear paired tubercles. Five pairs of posterior border spines are clearly visible on the lectotype (Pl. 116, fig. 3) and there is room for a sixth pair posteriorly.

Discussion. The form described above is extremely similar in many respects to *Diacanthaspis decacantha* (Angelin) described by Kielan (1960, pp. 103–106, pl. 15, figs. 1–3; pl. 16, figs. 2, 3; pl. 17, figs. 7, 8; text-fig. 27) from the Upper Ordovician of Sweden and Poland (see also Bruton, 1966, pp. 11, 12, pl. 2, figs. 7, 8) and by Whittington (1962, pp. 23–24, pl. 5, figs. 9, 16, 17, 20; 1965, pp. 33–34, pl. 9, figs. 1–10; 1968, pp. 99–100, pl. 30, fig. 24) from the Rhiwlas Limestone of North Wales. The cranidium is similar in all visible features (though Kielan's material does not show the eye-ridge) except that the longitudinal furrow is much more pronounced in the lectotype of *D.*? *turnbulli*, very distinctly separating the 2p lateral lobe from the median lobe of the glabella. In this respect, however, the lectotype differs from the two other cranidia known, which are more like *D. decacantha*, and the furrow has probably been emphasized by distortion. The thorax is strikingly similar and clearly shows the thickening of the pleural spines near the fulcrum (see moulds of ventral surfaces of spines in Pl. 116, fig. 3) which has been regarded (Whittington 1968, p. 99) as a feature characteristic of *D. decacantha.*

It seems probable that when more and better-preserved material is available (including the free cheek and pygidium), *Acidaspis turnbulli* Reed will prove to be a junior synonym of *D. decacantha* (Angelin). The likelihood of this is increased by the similarity of many of its associates in the Sholeshook Limestone to forms associated with *D. decacantha* in both Poland and North Wales (see Price 1973, table 2).

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